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(54) **Gas turbine of the axial flow type**

Axialdurchströmte Gasturbine

Turbine à gaz de type à flux axial

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to the technology of gas turbines. It refers to a gas turbine of the axial flow type according to the preamble of claim 1.

[0002] More specifically, the invention relates to designing a stage of an axial flow turbine for a gas turbine unit. Generally the turbine stator consists of a vane carrier with slots where a row of vanes and a row of stator heat shields are installed one after another. The same stage includes a rotor consisting of a rotating shaft with slots where a row of rotor heat shields and a row of blades are installed one after another.

PRIOR ART

[0003] The invention relates to a gas turbine of the axial flow type, an example of which is shown in Fig. 1. The gas turbine 10 of Fig. 1 operates according to the principle of sequential combustion. It comprises a compressor 11, a first combustion chamber 14 with a plurality of burners 13 and a first fuel supply 12, a high-pressure turbine 15, a second combustion chamber 17 with the second fuel supply 16, and a low-pressure turbine 18 with alternating rows of blades 20 and vanes 21, which are arranged in a plurality of turbine stages arranged along the machine axis 22.

[0004] The gas turbine 10 according to Fig. 1 comprises a stator and a rotor. The stator includes a vane carrier 19 with the vanes 21 mounted therein; these vanes 21 are necessary to form profiled channels where hot gas developed in the combustion chamber 17 flows through. Gas flowing through the hot gas path 29 in the required direction hits against the blades 20 installed in shaft slits of a rotor shaft and makes the turbine rotor to rotate. To protect the stator housing against the hot gas flowing above the blades 20, stator heat shields installed between adjacent vane rows are used. High temperature turbine stages require cooling air to be supplied into vanes, stator heat shields and blades.

[0005] A section of a typical air-cooled gas turbine stage TS of a gas turbine 10 is shown in Fig. 2. Within a turbine stage TS of the gas turbine 10 a row of vanes 21 is mounted on the vane carrier 19. Downstream of the vanes 21 a row of rotating blades 20 is provided each of which has at its tip an outer platform 24 with teeth (52 in Fig. 3(B)) arranged on the upper side. Opposite to the tips (and teeth 52) of the blades 20, stator heat shields 26 are mounted on the vane carrier 19. Each of the vanes 21 has an outer vane platform 25. The vanes 21 and blades 20 with their respective outer platforms 25 and 24 border a hot gas path 29, through which the hot gases from the combustion chamber flow.

[0006] To ensure operation of such a high temperature gas turbine 10 with long-term life time, all parts forming its flow path 29 should be cooled effectively. Cooling of turbine parts is realized using air fed from the compressor 11 of said gas turbine unit. To cool the vanes 21, compressed air is supplied from a plenum 23 through the holes 27 into the cavity 28 located between the vane carrier 19 and outer vane platforms 25. Then the cooling air passes through the vane airfoil and flows out of the airfoil into the turbine flow path 29 (see horizontal arrows at the trailing edge of the airfoil in Fig. 2). The blades 20 are cooled using air which passes through the blade shank and airfoil in vertical (radial) direction, and is discharged into the turbine flow path 29 through a blade airfoil slit and through an opening between the teeth 52 of the outer blade platform 24. Cooling of the stator heat shields 26 is not specified in the design presented in Fig. 2 because the stator heat shields 26 are considered to be protected against a detrimental effect of the main hot gas flow by means of the outer blade platform 24.

[0007] Disadvantages of the above described design can be considered to include, firstly, the fact that cooling air passing through the blade airfoil does not provide cooling efficient enough for the outer blade platform 24 and thus its long-term life time. The opposite stator heat shield 26 is also protected insufficiently against the hot gas from the hot gas path 29.

[0008] Secondly, a disadvantage of this design is the existence of a slit within the zone A in Fig. 2, since cooling air leakage occurs at the joint between the vane 21 and the subsequent stator heat shield 26, resulting in a loss of cooling air, which enters into the turbine flow path 29.

[0009] Document US 2004258523 A1 discloses a sealing assembly for contactless sealing between static components and moving components of a gas turbine which comprises a gas-permeable, abrasion-tolerant sealing element arranged opposite a sealing tip and secured in a support. In operation, a coolant can flow through the sealing element, for example a honeycomb element, due to its gas permeability, so the sealing element is cooled. A redundant coolant passage opens upstream of the sealing element on the hot-gas side of the assembly, so that coolant emerging therefrom flows over the sealing element on its hot-gas side. If the flow of coolant through the sealing element fails because flow through the sealing element becomes blocked, cooling is taken over by film coolant flowing out of the redundant cooling passage. Coolant mass flow is metered in via feeds, which effect the primary pressure loss in the device. The feeds may be designed as through-openings in an impingement cooling element.

[0010] Document EP1 366 271 B1 discloses a turbine for a gas turbine engine including a turbine nozzle assembly that facilitates reducing an operating temperature of rotor blades in a cost-effective and reliable manner is described. Each rotor blade includes a tip that rotates in close proximity to a shroud that extends circumferentially around the rotor assembly. The turbine nozzle assembly includes a plurality of turbine vane segments that channel combustion gases to downstream rotor blades. Each turbine vane segment extends radially outward from an inner platform and includes a tip, a root, and a body that extends therebetween. The turbine vane segment tip is formed integrally with an outer band that mounts the vane segments within the gas turbine engine. The outer band is in flow communication with a cooling fluid source, and includes at least one opening.

[0011] Document EP 1 213 444 B1 discloses a shroud segment for a shroud ring of a gas turbine. The shroud segment has an inner surface adapted to face the turbine blades in use. Path means is defined in the shroud segment which is adapted to extend, in use, generally parallel to the principal axis of the turbine and has downstream inlet means through which a cooling fluid to cool the shroud segment can enter the path means and upstream outlet means from which the cooling fluid can be exhausted from the path means. The cooling fluid can flow along the path means in a generally upstream direction opposite to the flow of gas through the turbine.

SUMMARY OF THE INVENTION

[0012] It is an object of the present invention to provide a gas turbine with a turbine stage cooling scheme, which avoids the drawbacks of the known cooling configuration and combines a reduction in cooling air mass flow and leakage with an improved cooling and effective thermal protection of critical parts within the turbine stages of the turbine.

[0013] This and other objects are obtained by a gas turbine according to claim 1.

[0014] The gas turbine of the invention comprises a rotor with alternating rows of air-cooled blades and rotor heat shields, and a stator with alternating rows of air-cooled vanes and stator heat shields mounted on a vane carrier, whereby the stator coaxially surrounds the rotor to define a hot gas path in between, such that the rows of blades and stator heat shields, and the rows of vanes and rotor heat shields are opposite to each other, respectively, and a row of vanes and the next row of blades in the downstream direction define a turbine stage, and whereby the blades are provided with outer blade platforms at their tips. According to the invention means are provided within a turbine stage to direct cooling air that has already been used to cool the airfoils of the vanes of the turbine stage, into a first cavity located between the outer blade platforms and the opposed stator heat shields for protecting the stator heat shields against the hot gas and for cooling the outer blade platforms, whereby the vanes each comprise an outer vane platform, the directing means comprises a second cavity for collecting the cooling air, which exits the vane airfoil, and the directing means further comprises means for discharging the collected cooling air radially into said first cavity.

[0015] According to the invention the outer blade platforms are provided on their outer side with parallel teeth extending in the circumferential direction, and said first cavity is bordered by said parallel teeth.

[0016] Preferably, the discharging means comprises a projection at the rear wall of the outer vane platform, which overlaps the first teeth in the flow direction of the adjacent outer blade platforms, and a screen, which covers the projection such that a channel for the cooling air is established between the projection and the screen, which ends in a radial slot just above the first cavity.

[0017] According to another embodiment of the invention the second cavity and the discharging means are connected by a plurality of holes, which are passing the rear wall of the outer vane platform and are equally spaced in the circumferential direction.

[0018] According to adjust another embodiment of the invention the second cavity is separated from the rest of the outer vane platform by means of a shoulder, and the second cavity is closed by a sealing screen of.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The present invention is now to be explained more closely by means of different embodiments and with reference to the attached drawings.

Fig. 1 shows a well-known basic design of a gas turbine with sequential combustion, which may be used for practising the invention;

Fig. 2 shows cooling details of a turbine stage of a gas turbine according to the prior art;

Fig. 3 shows cooling details of a turbine stage of a gas turbine according to an embodiment of the invention;

Fig. 4 shows in a perspective view the configuration of the outer platform of the vane of Fig. 3 in accordance with an embodiment of the invention, whereby all of screens are removed; and

Fig. 5 shows in a perspective view the configuration of the outer platform of the vane of Fig. 3 with all screens put in place.

DETAILED DESCRIPTION OF DIFFERENT EMBODIMENTS OF THE INVENTION

[0020] Fig. 3 shows cooling details of a turbine stage of a gas turbine 30 according to an embodiment of the invention and demonstrates the proposed design of the turbine stages TS, where cooling air is saved due to utilization of air used up in the vanes 31. The novelty of this proposal consists not only in cooling air savings, but also in effective protection of the outer blade platform 34 against hot gas from the hot gas path 39, due to a continuous sheet of cooling air discharged vertically from the slit (50 in Fig. 3(B)) into a cavity 41 between parallel teeth 52 on the upper side of the outer blade platforms 34 of the blades 32 with an a turbine stage TS. The slit 50 is formed by means of a screen 43 covering a projection

44 at the rear wall of the outer vane platform 35 (see Fig. 3, zone B, and Fig. 3(B)).

[0021] In general, cooling air from the plenum 33 flows into cavity 38 through the cooling air hole 37, passes a perforated screen 49 and enters the cooling channels in the interior of the vane airfoil. The cooling air used up in the vane 31 for cooling passes from the airfoil into a cavity 46 partitioned off from the basic outer vane platform 35 by means of a shoulder 48 (see also Fig. 4). Then, this air is distributed from the cavity 46 into a row of holes 45 equally spaced in circumferential direction. The cavity 46 is closed with sealing screen 47 (see also Fig. 5). A as already mentioned above, perforated screen 49 (see Fig. 5) is situated above the remaining largest portion of the outer vane platform 35, and air is supplied through the holes in this screen to cool the platform surface and to enter the internal vane airfoil cavity (not shown in the figures).

[0022] An important new feature of the proposed design is also the provision of the projection 44 on the rear wall of the vane outer platform 35 equipped with a honeycomb 51 on the underneath (see Figs. 3-5). The forward one of the teeth 52 of the outer blade platform 34, which prevents additional leakages of used-up air from the cavity 41 into the turbine flow path 39, is situated directly under the projection 44. Due to the presence of this projection, an additional gap (see Fig. 2, zone A) making way for cooling air leakages, is avoided.

[0023] Thus, efficient utilization of used-up cooling air makes it possible to avoid supply of additional cooling air to the stator heat shields 36 and to blade shrouds or outer blade platforms 34 because used-up air closes the cavity 41 effectively.

[0024] In summary, the proposed cooling scheme has the following advantages:

1. Air used up in a vane 31 is utilized to cool parts, especially outer blade platforms 34.
2. There is no need in additional air for cooling the stator heat shields 36.
3. A projection 44, which is covered by a screen 43, generates a continuous air sheet of cooling air, which, in combination with the forward tooth 52 of the outer blade platform 34, closes the cavity 41 located between the teeth 52 on the outer side of the outer blade platforms 34.
4. The proposed shape of the projection 44 on the outer vane platform 35 makes it possible to avoid additional cooling air leakages within the jointing zone (see A in Fig. 2) between the vanes 31 and the stator heat shields 36.
5. Used-up air penetrates through gaps between adjacent stator heat shields 36 into a backside cavity 42 (see Fig. 3) and prevents stator parts from being overheated.

[0025] Thus, a combination of vanes 31 with the projection 44 and a separate collector 46 to 48 for utilized air, as well as combination of non-cooled stator heat shields 36 and two-pronged outer blade platforms 34 with a cavity 41 formed between the outer teeth 52 of these outer blade platforms 34, enables a modern high-performance turbine to be designed.

LIST OF REFERENCE NUMERALS

[0026]

10,30	gas turbine
11	compressor
12,16	fuel supply
13	burner
14,17	combustion chamber
15	high-pressure turbine
18	low-pressure turbine
19,40	vane carrier (stator)
20,32	blade
21,31	vane
22	machine axis
23,33	plenum
24,34	outer blade platform
25,35	outer vane platform
26,36	stator heat shield
27,37	hole
28,38	cavity
29,39	hot gas path
41,42,46	cavity
43,47,49	screen
44	projection
45	hole
48	shoulder
50	slit
51	honeycomb
52	tooth (outer blade platform)
TS	turbine stage

Claims

1. Gas turbine (30) of the axial flow type, comprising a rotor with alternating rows of air-cooled blades (32) and rotor heat shields, and a stator with alternating rows of air-cooled vanes (31) and stator heat shields (36) mounted on a vane carrier (40), whereby
the stator coaxially surrounds the rotor to define a hot gas path (39) in between, such that the rows of blades (32) and stator heat shields (36), and the rows of vanes (31) and rotor heat shields are opposite to each other, respectively, and a row of vanes (31) and the next row of blades (32) in the downstream direction define a turbine stage (TS),
the blades (32) are provided with outer blade platforms (34) at their tips,
within a turbine stage (TS) means (43-48) are provided to direct cooling air that has already been used to cool the airfoils of the vanes (31) of the turbine

stage (TS), into a first cavity (41) located between the outer blade platforms (34) and the opposed stator heat shields (36) for protecting the stator heat shields (36) against the hot gas and for cooling the outer blade platforms (34),
the vanes (31) each comprise an outer vane platform (35),
the directing means (43-48) comprises a second cavity (46) for collecting the cooling air, which exits the vane airfoil, and the directing means (43-48) further comprises means (43, 44) for discharging the collected cooling air radially into said first cavity (41),
characterised in that
the cooling air passes through the vanes (31), and the outer blade platforms (34) are provided on their outer side with parallel teeth (52) extending in the circumferential direction, and said first cavity (41) is bordered by said parallel teeth (52).

2. Gas turbine according to claim 1, **characterised in that** the discharging means (43, 44) comprises a projection (44) at the rear wall of the outer vane platform (35), which overlaps the first teeth (52) in the flow direction of the adjacent outer blade platforms (34), and a screen (43), which covers the projection (44) such that a channel for the cooling air is established between the projection (44) and the screen (43), which ends in a radial slot just above the first cavity (41).

3. Gas turbine according to claim 1, **characterised in that** the second cavity (46) and the discharging means (43, 44) are connected by a plurality of holes (45), which are passing the rear wall of the outer vane platform (35) and are equally spaced in the circumferential direction.

4. Gas turbine according to claim 1, **characterised in that** the second cavity (46) is separated from the rest of the outer vane platform (35) by means of a shoulder (48), and the second cavity (46) is closed by a sealing screen (47).

Patentansprüche

1. Axialdurchströmte Gasturbine (30), umfassend einen Rotor mit wechselnden Reihen von luftgekühlten Laufschaufeln (32) und Rotorhitzeschilden und einen Stator mit abwechselnden Reihen von luftgekühlten Leitschaufeln (31) und Statorhitzeschilden (36), die auf einem Leitschaufelträger (40) befestigt sind, wobei
der Stator den Rotor koaxial umgibt, um einen Heißgasweg (39) dazwischen zu definieren, so dass die Reihen von Laufschaufeln (32) und Statorhitzeschilden (36) bzw. die Reihen von Leitschaufeln (31) und Rotorhitzeschilden einander gegenüberliegen und eine Reihe von Leitschaufeln (31) und die nächste Reihe von Laufschaufeln (32) in der stromabwärtigen Richtung eine Turbinenstufe (TS) definieren,
die Laufschaufeln (32) mit äußeren Laufschaufelplattformen (34) an ihren Spitzen versehen sind,
in einer Turbinenstufe (TS) ein Mittel (43 - 48) vorgesehen ist, um Kühlluft, die bereits zum Kühlen der Blätter der Leitschaufeln (31) der Turbinenstufe (TS) verwendet worden ist, in einen ersten Hohlraum (41) zwischen den äußeren Laufschaufelplattformen (34) und den gegenüberliegenden Statorhitzeschilden (36) zu lenken, um die Statorhitzeschilde (36) vor dem Heißgas zu schützen und die äußeren Laufschaufelplattformen (34) zu kühlen,
die Leitschaufeln (31) jeweils eine äußere Leitschaufelplattform (35) umfassen,
das Lenkmittel (43 - 48) einen zweiten Hohlraum (46) zum Sammeln der Kühlluft umfasst, die aus dem Leitschaufelblatt austritt, und das Lenkmittel (43 - 48) ferner ein Mittel (43, 44) zum radialen Austragen der gesammelten Kühlluft in den ersten Hohlraum (41) umfasst,
dadurch gekennzeichnet, dass
die Kühlluft durch die Leitschaufeln (31) geht und die äußeren Laufschaufelplattformen (34) an ihrer Außenseite mit parallelen Zähnen (52) versehen sind, die sich in der Umfangsrichtung erstrecken, und der erste Hohlraum (41) mit den parallelen Zähnen (52) umrandet ist.

2. Gasturbine nach Anspruch 1, **dadurch gekennzeichnet, dass** das Austragemittel (43, 44) einen Vorsprung (44) an der hinteren Wand der äußeren Leitschaufelplattformen (35), der die ersten Zähne (52) in der Strömungsrichtung der benachbarten äußeren Laufschaufelplattformen (34) überlappt, und einen Schild (43) umfasst, der den Vorsprung (44) so abdeckt, dass zwischen dem Vorsprung (44) und dem Schild (43) ein Kanal für die Kühlluft entsteht, der in einem radialen Schlitz knapp oberhalb des ersten Hohlraums (41) endet.

3. Gasturbine nach Anspruch 1, **dadurch gekennzeichnet, dass** der zweite Hohlraum (46) und das Austragemittel (43, 44) durch eine Vielzahl von Löchern (45) verbunden sind, die durch die hintere Wand der äußeren Leitschaufelplattform (35) gehen und in der Umfangsrichtung gleich beabstandet sind.

4. Gasturbine nach Anspruch 1, **dadurch gekennzeichnet, dass** der zweite Hohlraum (46) mittels einer Schulter (48) von der restlichen äußeren Leitschaufelplattform (35) getrennt ist und der zweite Hohlraum (46) durch einen Dichtschild (47) geschlossen ist.

Revendications

1. Turbine à gaz (30) du type à écoulement axial, comprenant un rotor avec une alternance de rangées d'aubes (32) refroidies par air et de boucliers thermiques de rotor, et un stator avec une alternance de rangées d'ailettes (31) refroidies par air et de boucliers thermiques de stator (36) montées sur un support d'ailettes (40),
le stator entourant coaxialement le rotor pour définir un chemin de gaz chaud (39) entre eux, de telle sorte que les rangées d'aubes (32) et de boucliers thermiques de stator (36), et les rangées d'ailettes (31) et de boucliers thermiques de rotor soient mutuellement opposées, respectivement, et une rangée d'ailettes (31) et la rangée suivante d'aubes (32) dans la direction aval définissant un étage de turbine (TS),
les aubes (32) étant pourvues de plates-formes d'aubes externes (34) au niveau de leurs pointes, des moyens (43-48) étant prévus à l'intérieur d'un étage de turbine (TS) pour diriger de l'air de refroidissement qui a déjà été utilisé pour refroidir les surfaces portantes des ailettes (31) de l'étage de turbine (TS), jusque dans une première cavité (41) située entre les plates-formes d'aubes externes (34) et les boucliers thermiques de stator (36) opposés, pour protéger les boucliers thermiques de stator (36) contre les gaz chauds et pour refroidir les plates-formes d'aubes externes (34),
les ailettes (31) comprenant chacune une plate-forme d'ailette externe (35),
les moyens pour diriger (43-48) comprenant une deuxième cavité (46) pour recueillir l'air de refroidissement qui sort de la surface portante d'ailette, et les moyens pour diriger (43-48) comprenant en outre des moyens (43, 44) pour décharger l'air de refroidissement recueilli radialement dans ladite première cavité (41), **caractérisée en ce que**
l'air de refroidissement passe à travers les ailettes (31), et les plates-formes d'aubes externes (34) sont pourvues, sur leur côté extérieur, de dents parallèles (52) s'étendant dans la direction circonférentielle, et ladite première cavité (41) est bordée par lesdites dents parallèles.

2. Turbine à gaz selon la revendication 1, **caractérisée en ce que** les moyens pour décharger (43, 44) comprennent une saillie (44) au niveau de la paroi arrière de la plate-forme d'ailette externe (35), laquelle chevauche les premières dents (52) dans la direction d'écoulement des plates-formes d'aubes externes adjacentes (34), et un écran (43), qui recouvre la saillie (44) de telle sorte qu'un canal pour l'air de refroidissement soit établi entre la saillie (44) et l'écran (43), lequel canal se termine par une fente radiale juste au-dessus de la première cavité (41).

3. Turbine à gaz selon la revendication 1, **caractérisée en ce que** la deuxième cavité (46) et les moyens pour décharger (43, 44) sont connectés par une pluralité de trous (45) qui passent à travers la paroi arrière de la plate-forme d'ailette externe (35) et qui sont répartis uniformément dans la direction circonférentielle.

4. Turbine à gaz selon la revendication 1, **caractérisée en ce que** la deuxième cavité (46) est séparée du reste de la plate-forme d'ailette externe (35) au moyen d'un épaulement (48), et la deuxième cavité (46) est fermée par un écran d'étanchéité (47).

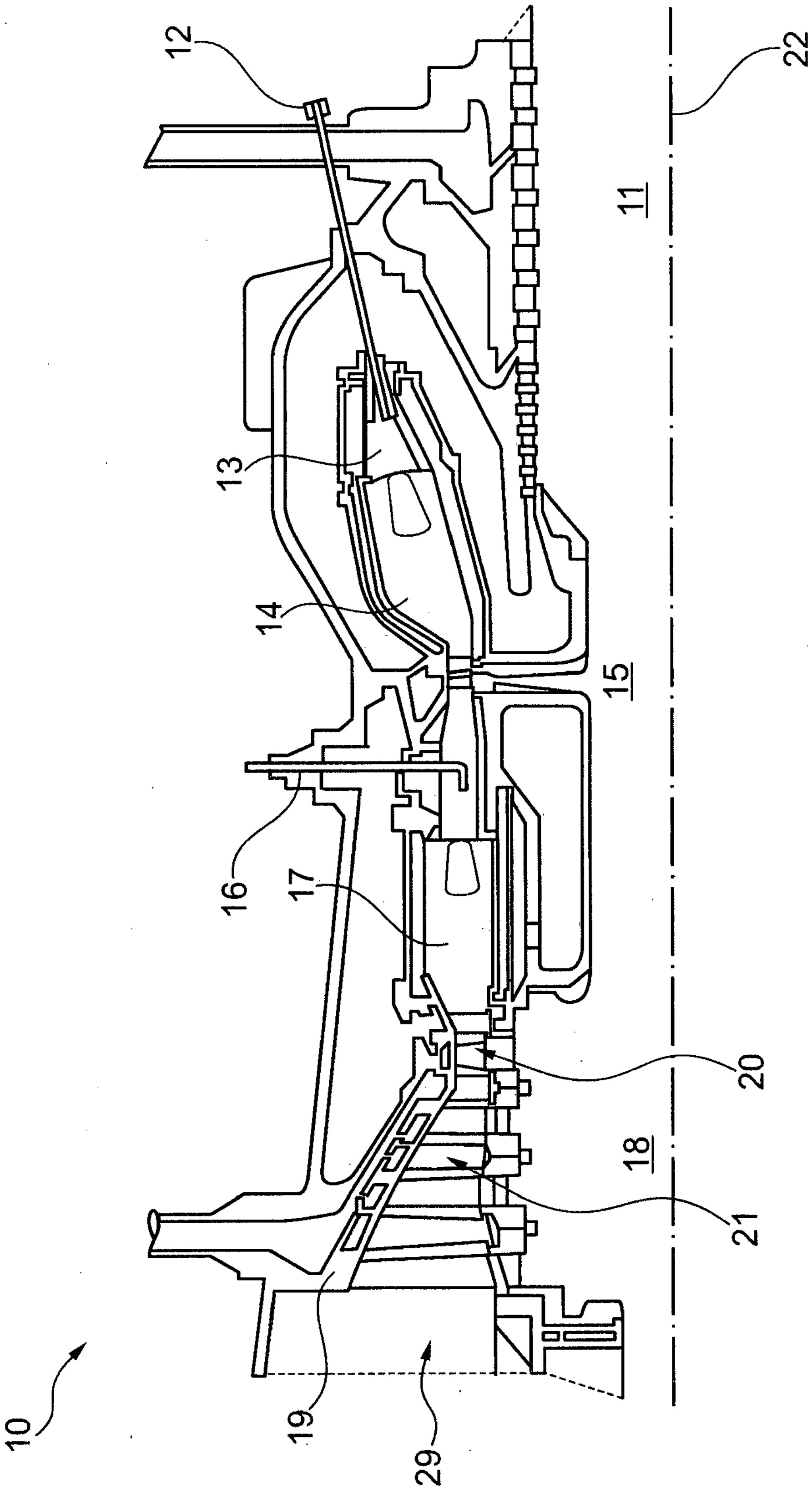

Fig. 1

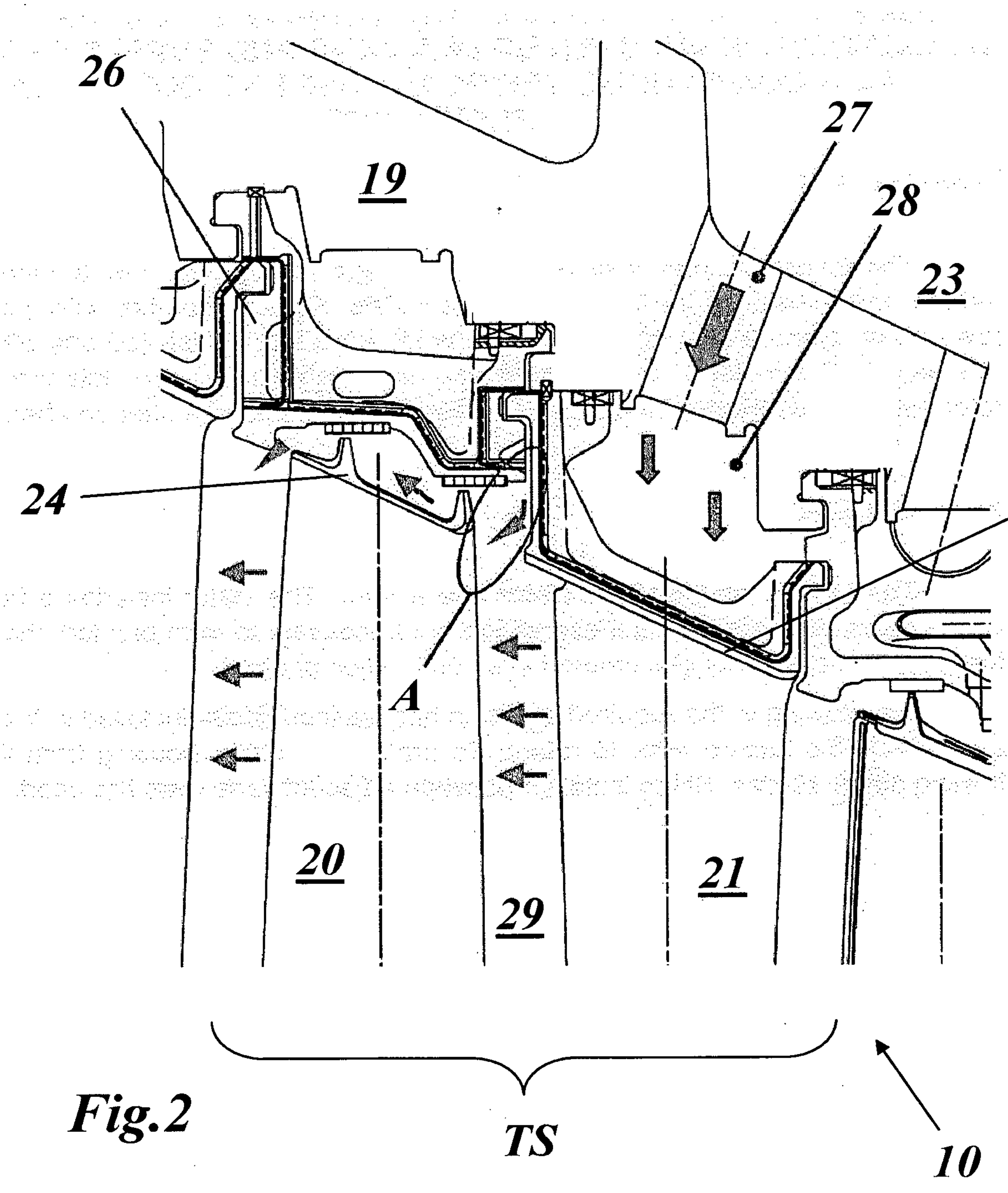

Fig.2

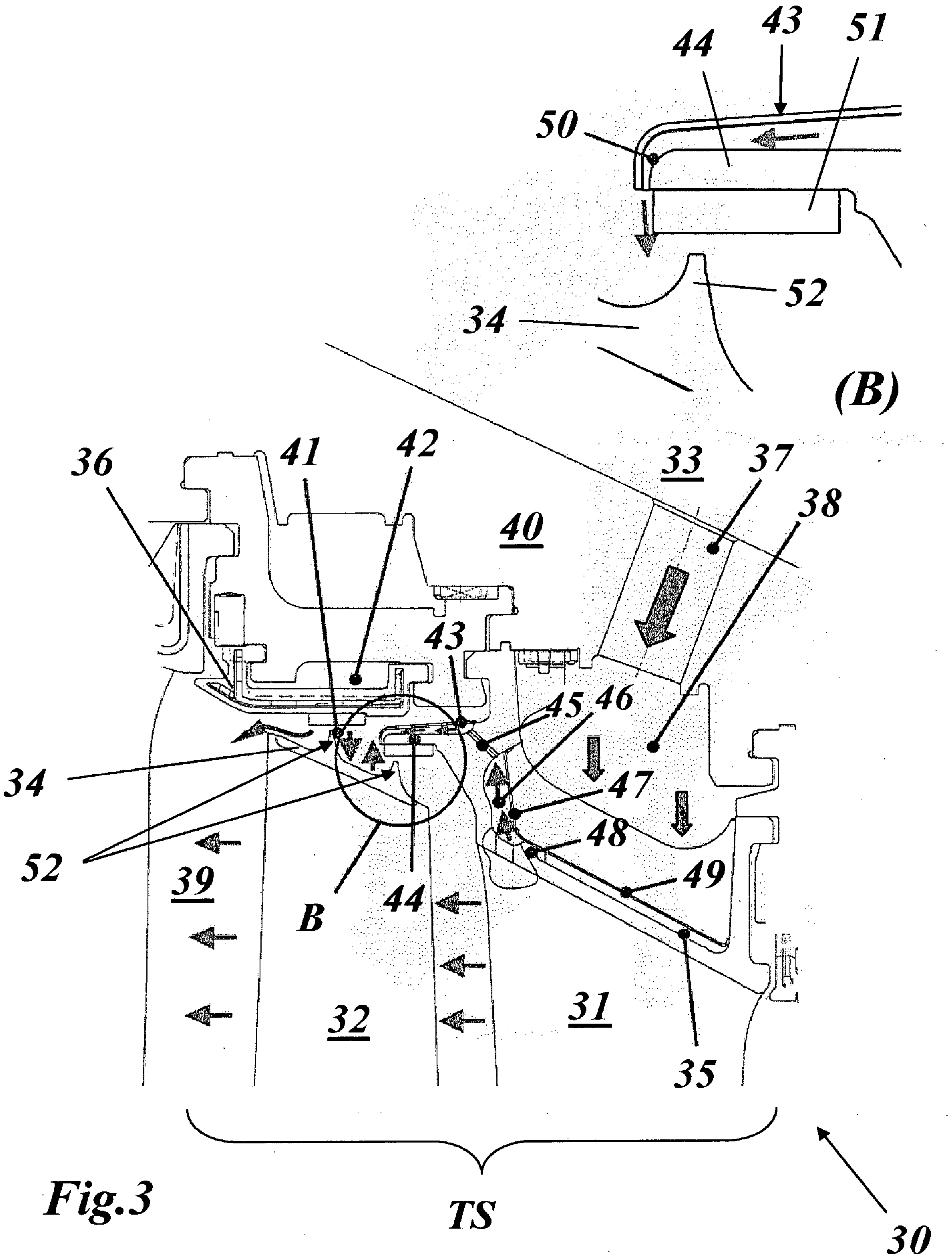
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Fig.3

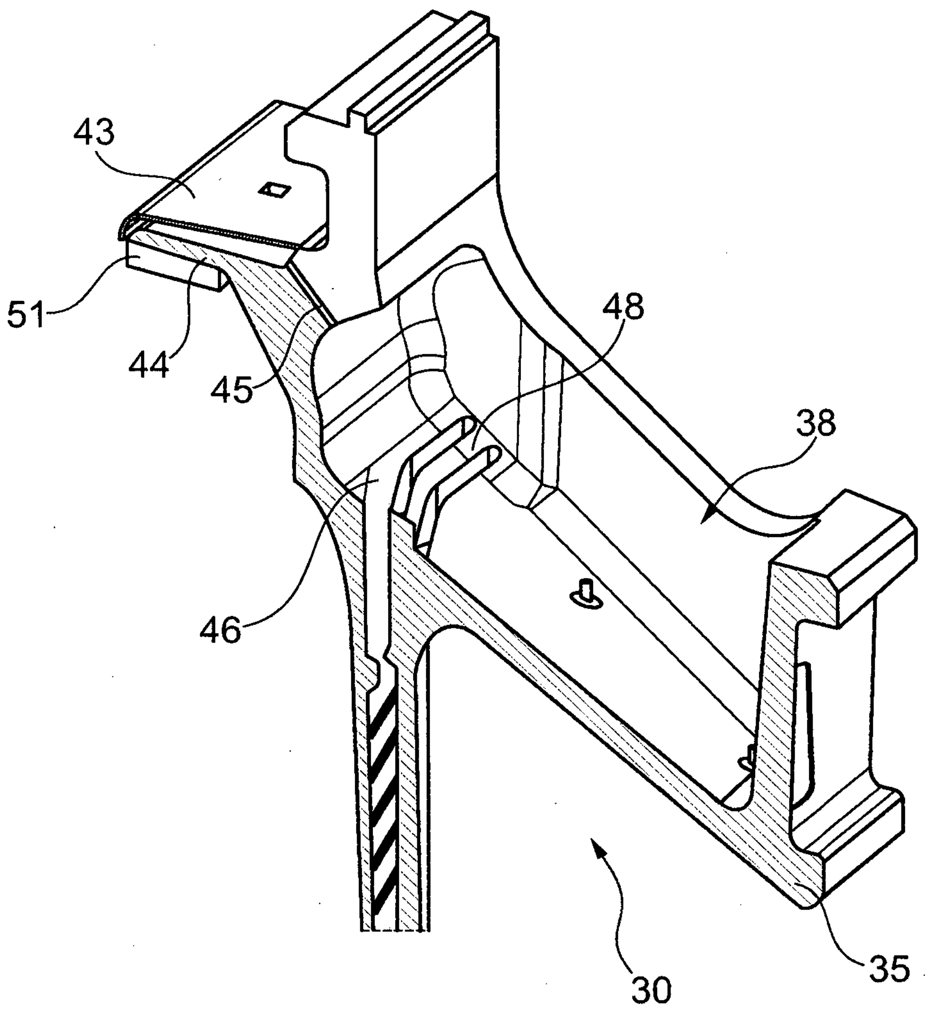

Fig. 4

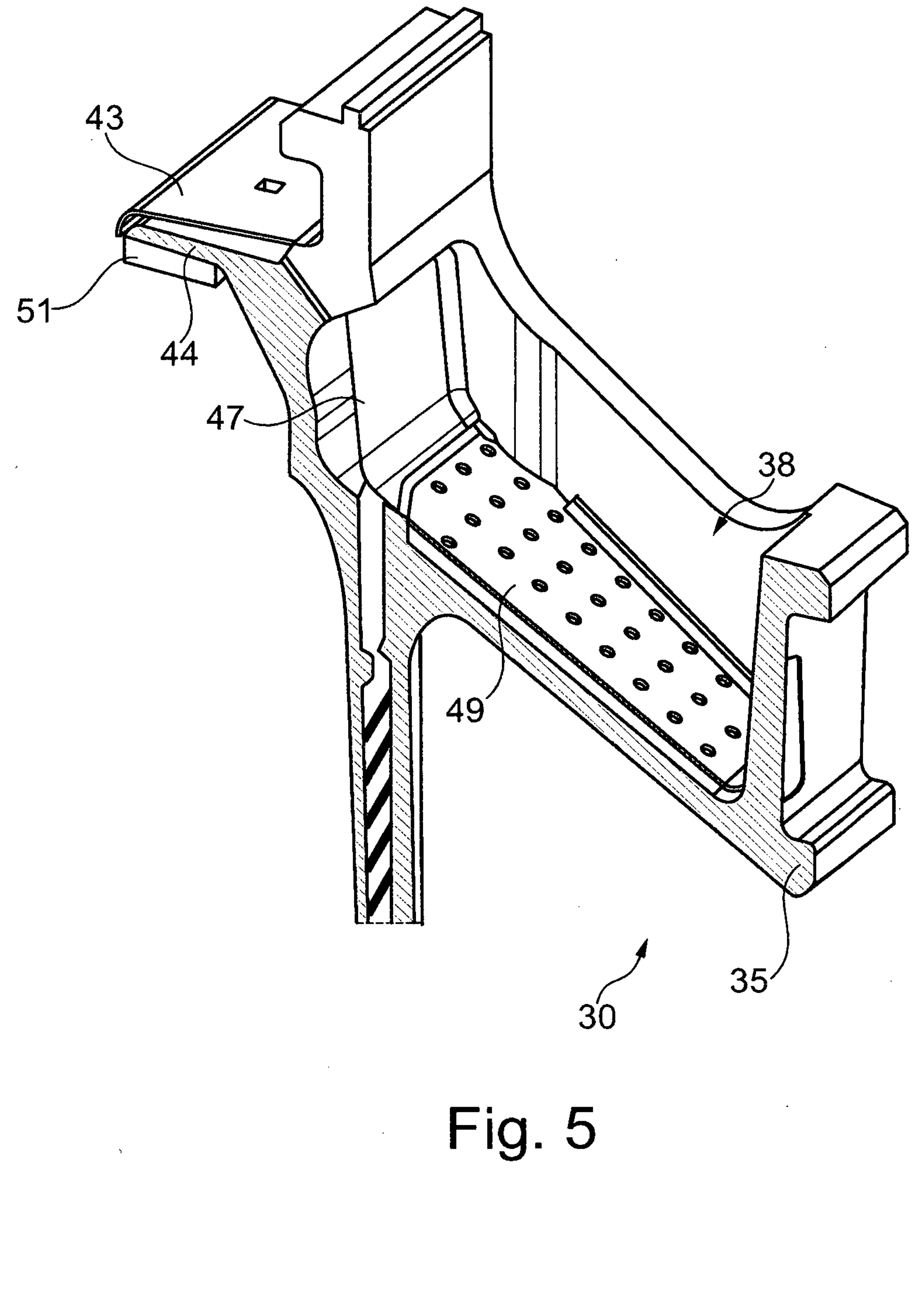

Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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